ATM OVER SATELLITE

INTEGRATION OF SATELLITE LINK INTO THE ATM PILOT: NO PROBLEM

This paper presents the results of the integration tests of the satellite link in the European ATM pilot network performed during December 1994. These tests have been carried out by the European Telecommunication Satellite Organization, EUTELSAT, in association with three PNOs, Telefonica, Telia and Swiss Telecom PTT, and have been organized to prove that a satellite link does not introduce transmission constraints. This paper contains an overview of the configuration used during these tests and the results of ATM-specific measurements [1] from one cross-connect equipment to another.

EUTELSAT has suggested to the PNOs the possibility of introducing satellite links in the transmission backbone of the ATM pilot network, which is mostly based on 34-Mbit/s links, in

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order to validate and prove the viability of satellite communications for different B-ISDN services.

A pilot network using ATM techniques has been implemented between Switzerland, Sweden and Spain. The three following earth stations were involved in these tests: Basel-2 (Swiss Telecom PTT), Aagesta (Telia) and Guadalajara-11 (Telefonica).

The ATM traffic passed over several national and international cross-connect equipment located in Zürich (Swiss Telecom PTT), Göteborg and Haninge (Telia), Alcobendas and Norte (Telefonica). *Figure 3* gives the connectivity scenario used during these tests.

The aim of this trial was firstly to prove that the interconnection of the ATM cross-connect equipment via a 34-Mbit/s satellite link worked properly and secondly to facilitate broadband experiments between research and development (R&D) laboratories. Another objective of this trial is to develop solutions for potential future multimedia applications and services [2].

EUTELSAT, with the assistance of CSELT (Italy) and Swiss Telecom PTT, carried out during last summer a com-

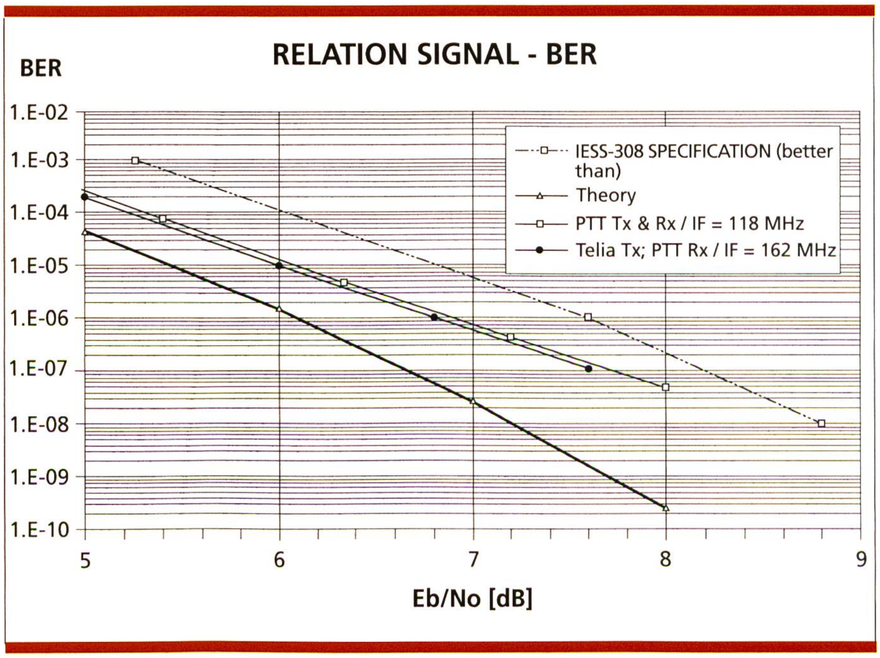

Fig.1. Relation between the signal degradation and the BER.

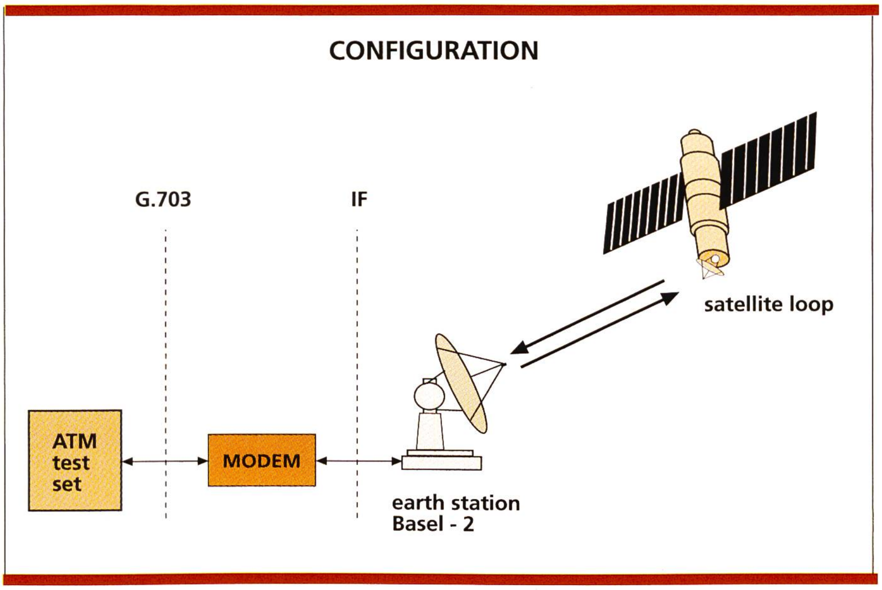

Fig. 2. Experiment configuration during field trials done in Basel.

prehensive assessment of the impact of the use of satellite links on the transfer of ATM cells [3].

Test results

The field trials were the first ones of this type organized in Europe. A first series of tests of ATM transmissions over satellite links were carried out at the Swiss Telecom PTT premises in Basel.

Validation of the satellite link

These tests have been performed on the EUTELSAT satellite II-F3, transponder 37 for the first phase of this trial, and on satellite I-F5, transponder 10 for the second phase. Intermediate data rate (IDR) modems with a bit rate of 34 Mbit/s, 3/4 FEC and V.35 scrambler have been used.
These tests are related to the quality of the satellite link. A pseudorandom sequence generator at 34 Mbit/s and a bit error ratio (BER) analyser synchronized on the same pseudorandom sequence on the other side of the link were used. By inserting noise on intermediate frequency at the demodulator input, BER measurements have been done for some values of Eb/No (which is the ratio between energy per uncoded bit and noise power per 1 Hz bandwidth).
Figure 1 illustrates a typical measurement of BER versus Eb/No. The channel unit shall meet the Intelsat Earth Station Standards (IESS).

First phase of ATM layer measurements

In the first phase, the ATM test set generated and analysed a 34-Mbit/s PDH framed ATM cell stream which was transmitted over the satellite configured in loop back. Different measurements have been done with nominal Eb/No. No errors were encountered. The results obtained prove the viability of satellite links in ATM networks. No significant errors have been found when testing ATM transport over satellite links under nominal conditions.
Then, some other tests have been carried out with deliberately degraded links. Noise was added on the satellite link (at the demodulator input, on the intermediate frequency). Bit errors happened in the data stream, which caused ATM cell losses.
Results show that the relation between cell loss ratio CLR and BER is more or less a linear relation: CLR $\cong$ BER $\times$ 6.
This result was expected, because the header error control (HEC) mechanism is not efficient, if bit errors occurred as error bursts. This HEC is designed to correct single bit errors. If there are multiple header bits in error and they are detected, the entire cell is lost.
The relation between CLR for random bit errors and BER is CLR $\cong$ 2400 $\times$ BER2 [4].
The results have shown the impact of error bursts on satellite links. CLR (due to discarded cells and miscorrected cells) becomes the most stringent criterion to dimension a satellite link with conventional IDR modems carrying a PDH-framed ATM cell stream.
The field trial configuration is given in *Figure 2,* and the characteristics of the basic equipment used in Basel are reported in *Table 1.*

Second phase of ATM layer measurements

In a second phase, three kinds of tests have been performed via satellite to validate the interconnection of the three ATM nodes, using ATM test equipment:
- cell loss ratio (CLR)
- cell transfer delay (CTD)
- cell delay variation (CDV)

Figure 3 gives the connectivity scenario used during these tests.
No cell loss has been recorded over the measurement period under clear-sky conditions. Therefore, some artifi-

modem	**Newtec NTC/2038/AA, NTC/2039/AA**
● **earth station** ● antenna diameter ● HPA ● EIRP ● G/T	SUI-BAS-2 9.0 m 600 W 74.5 dBW (oper.), 80.0 dBW (max.) 34.0 dB/K (clear sky)
satellite	EUTELSAT II-F3 (16° E), K_u band

Table 1. Characteristics of the basic equipment used in Basel.

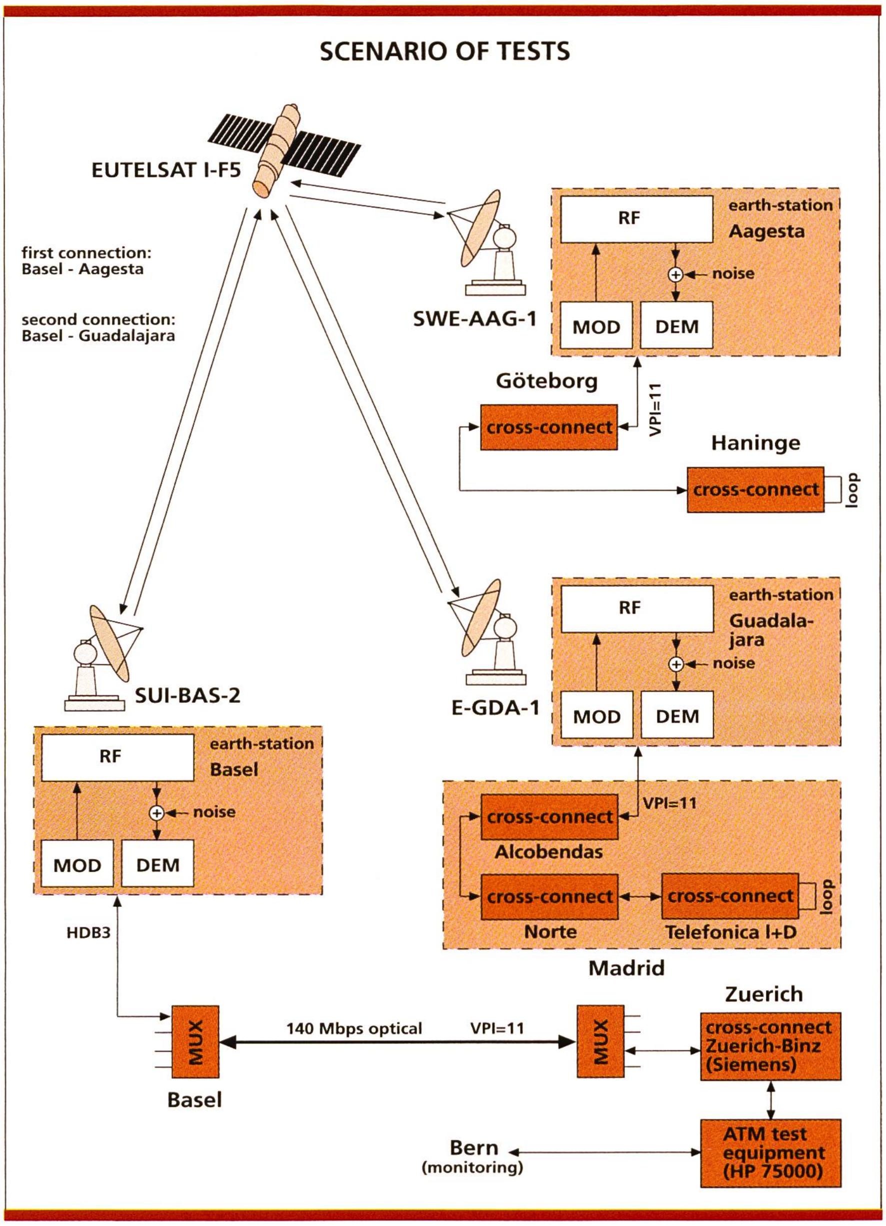

Fig. 3. Scenario used in field trials between the three PNOs.

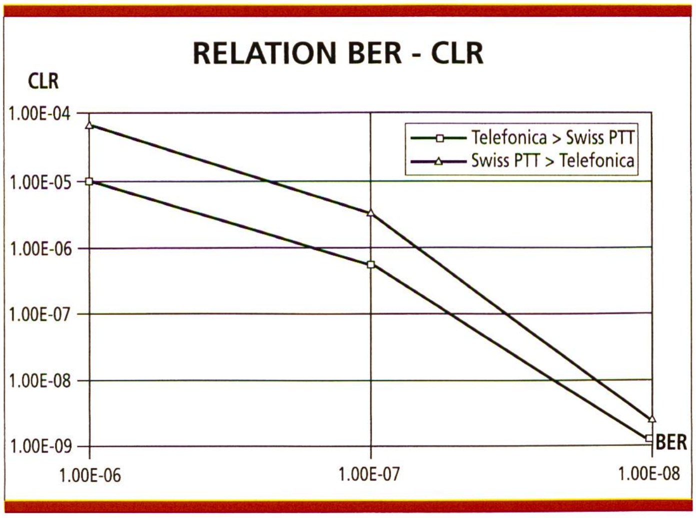

Fig. 4. Relation between BER and CLR of the ATM layer.

cial degradation has been introduced by inserting noise on intermediate frequency at the demodulator input to evaluate the effect of bit errors on the ATM physical layer. The results given in *Figure 4* have been obtained between Telefonica and Swiss Telecom PTT. Very similar results have been obtained between the other partners.

The main difference between a satellite link and a terrestrial link is characterized by the cell transfer delay (CTD). The CTD has been measured for a couple of bit rates, and a value of about 530 ms has been measured. (Note that this delay includes two satellite hops and at least three ATM nodes.)

The cell delay variation (CDV) has also been measured. The value measured was about 50 ms. This value was expected, because there is no cell manipulation on the satellite. The CDV value is not influenced by the satellite, it is only influenced by the number of cross-connect equipment.

CONCLUSION

This experiment proved that the integration of the satellite link into the ATM pilot network does not cause any problems.

Special considerations should be given to the influence of the transmission delay introduced by satellite link on the higher layer data communication protocols.

The cell loss ratio is certainly the most stringent criterion to dimension an operational ATM satellite link with conventional modem. A more effective dimensioning of an operational satellite link can be obtained through the use of Reed Solomon outer coding [5]. With a Reed Solomon outer coding, the improvement in performance is significant; it could virtually eliminate all errors at nominal Eb/No levels. A satellite link with Reed Solomon outer coding is either quasi error-free or not available. The required availability can be reached by appropriate system planning. Typical values are up to 99.98 % in the average year.

operator:	cross-connects	ATM test equipment
Swiss Telecom PTT	Siemens	HP 75 000
Telia	AT&T	Parasol
Telefonica	AT&T / Alcatel	HP 75 000

Table 2. Overview of the equipment used during these tests.

References

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Pascal Meuret is an electronic engineer; he received his diploma from the Engineering School of Biel after having visited the Technical School of St-Imier. In 1981 he began to work for Hasler AG (now Ascom) in the Telecommunication Development Department. He used to develop some telecommunication modules for the telex equipment. In 1988 he started working for the General Directorate PTT in the satellite section, and he had to deal with the planification of the digital transmission equipment. In 1990 he joined the R&D Department, and he participated in some projects, such as interconnection of LANs via satellite. He also studied the performances of some protocols, such as TCP/IP. Recently he collaborated with ESA (European Space Agency) regarding performances of ATM and SDH over satellite.